(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 548 695 A2**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **92121085.2**

(51) Int. Cl.5: **G06F 15/70**, A24C 5/34

(22) Date of filing: **10.12.92**

(30) Priority: **27.12.91 JP 347080/91**

(43) Date of publication of application:
30.06.93 Bulletin 93/26

(84) Designated Contracting States:
DE GB

(71) Applicant: **Japan Tobacco Inc.**
4-12-62 Higashishinagawa
Shinagawa-ku, Tokyo 140(JP)
Applicant: **TOSHIBA ENGINEERING CORPORATION**
66-2, Horikawacho, Saiwai-ku
Kawasaki-shi, Kanagawa 210(JP)

(72) Inventor: **Futamura, Tsuyoshi, c/o Japan Tobacco Inc.**
12-62, Higashi Shinagawa 4-chome
Shinagawa-ku, Tokyo 140(JP)
Inventor: **Suda, Hiroyoshi, c/o Japan Tobacco Inc.**
Seisan Gijutsu Kaihatsu Center, 1-31, Kurobeoka
Hiratsuka-shi, Kanagawa, 254(JP)
Inventor: **Fujita, Minoru, Toshiba Engineering Corporation**
66-2, Horikawacho, Saiwai-ku
Kawasaki-shi, Kanagawa, 210(JP)
Inventor: **Ichiba, Kouzou, Toshiba Engineering Corporation**
66-2, Horikawacho, Saiwai-ku
Kawasaki-shi, Kanagawa, 210(JP)

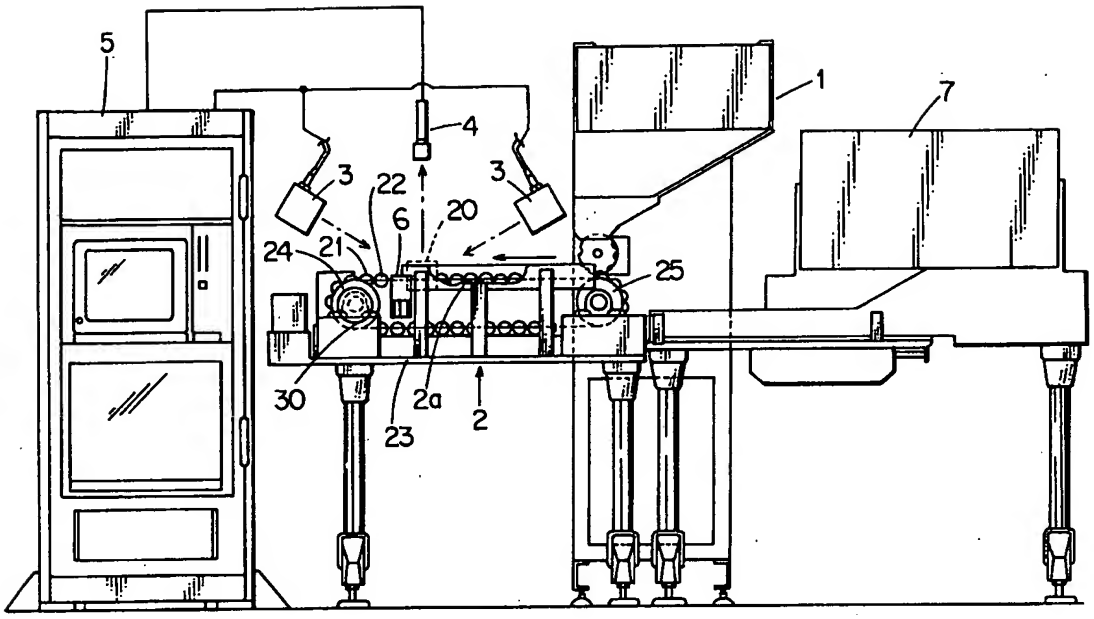
(74) Representative: **Reinhard, Skuhra, Weise**
Friedrichstrasse 31
W-8000 München 40 (DE)

(54) Apparatus for inspecting appearance of cylindrical objects.

(57) This invention relates to an apparatus for automatically inspecting abnormality in external surface, dirt on the surface, and poor shape of cylindrical objects by using image processing. The apparatus for inspecting the appearance of the cylindrical object according to the present invention comprises: rotating means for rotating the cylindrical object about an axis of the cylindrical object; picking up means for picking up images showing the appearance of the inspected object which are axially and circumferentially divided into a predetermined number; masking window generating means for generating masking windows for masking characters and symbols which are printed on an axially predetermined portion of the divided picked-up images of the inspected object; detecting window generating means for generating detecting windows for extracting portions on the axially predetermined portion of the divided picked-up images of the inspected object on which the characters and symbols are not printed; adding means for adding luminance excluding the luminance of the masking window for divided picked-up images each; and comparing means for comparing the added luminance with a predetermined threshold, wherein a portion where the added luminance exceeds the threshold is judged to be defective.

EP 0 548 695 A2

FIG. 1



BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an apparatus for inspecting appearance of cylindrical objects and more particularly to an apparatus for automatically inspecting abnormality in external surface, dirt on the surface, and poor shape of cylindrical objects by using image processing.

2. Description of the Prior Art

[Prior Art]

In industrial mass production, automation of producing and inspecting systems has been pushed ahead to rationalize production process. The inspection of appearance of products, which is one of the matters to be rationalized, is mainly performed through visual observation. However, in recent years, it has been developed with the spread of the computers that images which are picked up by a television camera (hereinafter merely called as "camera") are processed by a computer. The technic in which the picked up image is processed by the computer has been developed and adapted to automatically inspect the appearance of the products.

In the apparatus for inspecting the appearance with image processing, the images picked up by the camera are converted into analog signals. Then, the signals are converted into digital signals so as to be discriminated by the computer.

As a method of discriminating or inspecting the appearance with a computer, it has been generally used that an image of a standard product or an acceptable product (hereinafter merely called as "a standard image"), which is stored in the computer in advance, is compared with an image of an inspected object (hereinafter merely referred as "an inspected image"). Then, if there is a point or portion of the inspected image that does not correspond with the standard image, the inspected object relating to the image is judged to be a defective. On the other hand, when the standard image and the inspected image coincide with each other, the inspected object relating to the inspected image is judged to be an acceptable product. In the discriminating method with such standard image, even though characters or symbols are printed on the external surface of the inspected object, the inspecting operation can be carried out in consideration of the existence of the characters, symbols or the like.

Besides the above method, there is another method in which luminance signals of the image which is picked up by the camera are digitized and the luminance is integrated in a prescribed range to judge the inspected object as a defective product when the integrated luminance exceeds a predetermined threshold.

As described above, in the method of comparing the standard image with the inspected image, an entrapping start point and a finishing point must always coincide with those of the standard image and the inspected object is limited to be a polygon with symmetrical shape.

When the appearance of the cylindrical object is inspected based on the image picked up by the camera, an overall image of the object including external periphery should be entrapped. As described above, in the method of inspecting the appearance of the cylindrical object, the inspected object is rotated while the camera being fixed or the camera is rotated about the inspected object to pick up the appearance of the inspected object. The method in which the inspected object itself is rotated while the camera being fixed is preferable since in the other method, mounting and rotating mechanisms for the camera become rather complicated.

Further, in the method of rotating the inspected object, the rotating operation should be changed in accordance with the diameter of the inspected object. That is, when the diameter is small, the inspected object is preferably rotated with an axis of the inspected object being laid horizontally. Otherwise, the structure for maintaining and supporting the inspected object become complicated.

However, in the method of inspecting the appearance of the cylindrical object by entrapping the overall image of the object, it is difficult to compare the inspected image with the standard image since the start point of entrapping the inspected object does not always coincide with that of the standard image.

That is, in mass production of the cylindrical object, the appearance of the inspected objects must be inspected while the object being automatically transported by conveyors or the like. Therefore, it is difficult to fix the start point of the image of the inspected object at the inspection of the appearance thereof due to the mechanism of the transporter. To eliminate the problem, not only the transporting mechanism will become complicated but also the speed of the inspection will be decreased.

As a result, it is proposed that the luminance of the inspected object is summed up to inspect the appearance of the cylindrical object, which requires the appearance inspection in consideration of characters or symbols on the outer periphery of the inspected object.

SUMMARY OF THE INVENTION

It is therefore the object of the present invention to provide an apparatus for inspecting the appearance of the cylindrical objects on which characters or symbols are printed at the outer periphery thereof are picked up by a camera to judge defective objects.

The apparatus for inspecting the appearance of the cylindrical object according to the present invention comprises: rotating means for rotating the cylindrical object about an axis of the cylindrical object; picking up means for picking up images showing the appearance of the inspected object which are axially and circumferentially divided into a predetermined number; masking window generating means for generating masking windows for masking characters and symbols which are printed on an axially predetermined portion of the divided picked-up images of the inspected object; detecting window generating means for generating detecting windows for extracting portions on the axially predetermined portion of the divided picked-up images of the inspected object on which the characters and symbols are not printed; adding means for adding luminance excluding the luminance of the masking window for divided picked-up images each; and comparing means for comparing the added luminance with a predetermined threshold, wherein a portion where the added luminance exceeds the threshold is judged to be defective.

It is another object of the present invention to provide the apparatus for inspecting appearance of a cylindrical object described above further comprising subdivided windows which are obtained by further subdividing the detecting windows and counting means for counting the number of windows having luminance which exceed a predetermined threshold which is independently set for the subdivided windows each, wherein the appearance of the cylindrical object is judged to be defective when the number of windows exceeds a predetermined number.

In the apparatus for inspecting appearance of cylindrical object according to the present invention, the cylindrical inspected object is rotated about the axis of the object so that the appearance of the object is picked up by a camera or the like. At that time, the appearance of the inspected object is circumferentially divided into a predetermined number and axially divided images are picked up. Further, masking windows mask characters and symbols printed on a certain portions of the inspected object and adding means add luminance of the windows excluding masked windows for the divided picked-up images each. Then, when the sum of the luminance exceeds the threshold, corresponding portions are judged to be defective.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be more apparent from the ensuring description with reference to the accompanying drawing wherein:

Figure 1 is a schematic view of a transporter using an inspection apparatus according to an embodiment of the present invention;

Figure 2 is a block diagram of a controller according to the embodiment;

Figure 3 shows the relation between an extracted image and an overall image of an inspected object according to the embodiment;

Figure 4 is a graph showing luminance of image information of the inspected object according to the embodiment;

Figure 5 is a graph showing luminance of the inspected object and background according to the embodiment;

Figure 6 shows a masking window at the inspection of cigarettes according to the embodiment;

Figure 7 shows a window at the inspection of cigarettes according to the embodiment;

Figure 8 shows a discoloration due to heater of cigarettes according the embodiment;

Figure 9 shows detecting operation of manufacturing numbers of cigarette according to the embodiment;

Figure 10 shows detecting operation of defects on a paper roll of a cigarette according to the embodiment; and

Figure 11 is a flowchart showing image information processing and judging procedures according to the embodiment.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Figure 1 is a schematic view of a cigarette transporter with an appearance inspecting apparatus for a cylindrical object according to an embodiment of the present invention.

In the figure, reference numeral 1 is a hopper, 2 a transporter, 3 stroboscopes, 4 a CCD camera, 5 a controller, 6 a removing device, and 7 a pool. A cigarette is fed to a transporting route 2a of the transporter 2 from the hopper 1 one after another. At one end of the transporting route 2a is formed an inspecting section where a pair of stroboscopes 3 emits flush light to the transported cigarette and an image of the cigarette is picked up by the CCD camera 4 .

Then, defects of the cigarette are detected by the controller 5 based on the image information and cigarettes which are judged to be defective are removed by the removing device 6 such as an air nozzle. Nondefective cigarettes are transported by the transporter 2 to the pool 7 where the cigarettes

are stocked.

Reference numeral 21 are rotating rollers, 22 a chain, 23 a frame, 24 and 25 sprockets, and 30 a rotary encoder. The sprocket 24 is rotated by a driving source not shown to move the chain 22 and the rotating roller 21 in the direction as indicated by an arrow. The rotating rollers 21 move with being rotated on a guide not shown on the transporting route, which causes the cigarettes between the rotating rollers 21 to move while being rotated.

In the transporter described above, the image information picked up by the CCD camera at the inspection section 20 is image-processed by the controller 5. The controller 5 comprises, as illustrated in Fig. 2, a control panel 51, power sources 52 of the stroboscopes, a high speed image-processing apparatus 53, a personal computer 54, a first monitor 55, a second monitor 56, a video hard copying machine 57, and a serial printer 58.

To the control panel are inputted detecting signals for detecting cigarettes from a reflective photoelectric sensor 20a, pulse signals from the rotary encoder 30, and defective product detecting signals from the high speed image-processing apparatus 53. On inputting the detecting signal to the control panel from the reflective photoelectric sensor 20a, a command signal for causing the stroboscopes 3 to emit light for the high speed image-processing apparatus 53 on a controlled cycle and another command signal for starting the pick up of the image are outputted, and the pulse signals from the rotary encoder 30 are outputted to the high speed image-processing apparatus 53 to allow the stroboscope 3 to emit pulse light.

The high speed image-processing apparatus 53 reads the image data out of the CCD camera 4 in synchronization with timings that the stroboscopes 3 emit light and the image data for a single cigarette is stored in a range which is set in advance. Further, on starting the entrapping of the image, a detecting signal is outputted to the personal computer 54. To the first monitor 55 is outputted an image in which the luminance of the entrapped image are processed and to the second monitor 56 analog signals from the CCD camera 4.

The timing that the stroboscopes 3 emit light is calculated from the rotary encoder 30 which is attached to a driving shaft of the sprocket 24. The cycle that the stroboscopes emit light, in other words, the intervals that the images are inputted are set at 37.5 micro seconds and the image of the cigarette is picked up while the image of the cigarette being divided into six equal sections for every 60 degree of rotating angle to obtain the overall image of the outer periphery of the cigarette.

The method of picking up the image will be explained in detail with reference to Fig. 3. An image gi is extracted from an image of the cigarette for a rotation angle of 60 degree which is picked up by the CCD camera 4 and is within a visual field of the camera 4. The extracted image gi covers a certain range about the axis of the image of the cigarette for the rotation angle of 60 degree. Images obtained for the rotation angle of 60 degree are denoted g1 to g6 and a synthesized image G of the overall periphery of the cigarette is stored. The fault of each cigarette is checked based on these six images g1 to g6. In this embodiment, the visual field of the CCD camera 4 is 103.4 mm x 80.0 mm and the width of the image thereof for the rotation angle of 60 degree corresponds to 24 picture elements.

Luminance signals of six images, for example, those of one horizontal line (512 picture elements) outputted from the CCD camera 4 are shown in Fig. 4. The luminance of white portions of the cigarette paper and filter becomes high and portions of the cigarette paper where manufacturing number is printed, or portions where the cigarette paper is torn, or portions of the filter where the brand is printed become low in luminance. Then, the luminance of the picture elements each is converted into numerical data so as to be stored in the high speed image-processing apparatus 53.

The luminance picked up by the CCD camera are horizontally or vertically added to obtain a horizontal luminance information H and vertical luminance information V as shown in Fig. 5. Those information show that the luminance of the portion of the cigarette is different from that of the other portion. The images extracted at the rising and falling of the horizontal or vertical information correspond to the images from g1 to g6. In other words, there is a characteristics in the horizontal and vertical information for every 60 degree of the rotation angle and the combination of the information will provide the information on the images from g1 to g6 to form the synthesized image illustrated in Fig. 3

Meanwhile, when detecting abnormality such as tear and dirt on a cigarette based on the luminance information, discoloration due to heater, which may be generated while a pasted portion of the cigarette paper is dried by a heater, dirt due to ink which is used for printing characters or symbols on the cigarette paper, and dirt due to oil leakage from manufacturing machine are detected. The discoloration due to heater is observed at a certain portion but the luminance of the portion is not decreased remarkably. Further, it is difficult to distinguish a dirt in the characters or the symbols from the characters themselves or the dirt.

Therefore, as shown in Fig. 6, windows are required for extracting the luminance information of particular ranges or for masking the luminance information on the characters or symbols in accor-

dance with inspected items.

The explanation will be made on the windows with reference to Fig. 7. A heater discoloration window W1 is set at a portion of the cigarette paper excluding the portion where the manufacturing number is printed. A cigarette paper window W2 for detecting the dirt or tear of the cigarette paper is set at an area of the cigarette paper. Further, a filter window W3 for detecting the dirt on the filter is set at the filter area. A manufacturing number window W4 for masking the manufacturing number and a printing window W5 for masking the brand or the like are provided.

The cigarette paper window W2 and the filter window W3 are further divided vertically and horizontally to improve discriminating operation. In other words, a large fault or a plurality of small faults on the cigarette paper may indicate the same sum of the luminance as described below, which may cause a cigarette with small abnormality, which should be judged to be a nondefective, to be a defective product. To eliminate the problem, a number of small windows are used. The inspection of the cigarette is carried out with the windows for discriminating and masking as described below.

In case of detecting the discoloration due to heater, as illustrated in Fig. 8, the luminance of the picture elements each in the heater discoloration window W1, which is located prescribed position of the visual field S, are added for each of the six images with input numbers 1 to 6. As a result, the sum of the luminance for the images each is obtained as indicated by dots in the figure. Then, the sum is compared with a predetermined threshold. When the discoloration due to heater is observed in the image with input number 2 as illustrated in the figure, the sum of the luminance X1, X2 in the figure which exceeds the predetermined threshold indicates that the discoloration due to heater is generated.

Next, the method of detecting the tear and dirt of the cigarette paper will be explained with reference to Fig. 9. The luminance of the picture elements each in the manufacturing number window W4, which is located prescribed position of the visual field S, are added for each of the six images with input numbers 1 to 6. Then, the sum of the luminance for the images each is calculated as indicated by dots in the figure so as to be compared with a predetermined threshold which is set in advance as shown in the figure. When the manufacturing number is printed on the image with input number "4" as illustrated in the figure, the sums of the luminance Y1 and Y2 which exceed the predetermined threshold are obtained to detect the window for masking the portion where the manufacturing number is printed.

Further, as illustrated in Fig. 10, the sum of the luminance of picture elements of windows each which is obtained by subdividing the cigarette paper window 2 for six images with input numbers 1 to 6 is calculated for the subdivided windows each. When faults such as damage or tear, which indicate high luminance, is to be detected, a window corresponding to the manufacturing number is masked. Then, when the sum of the luminance of the other windows each exceeds the prescribed threshold, the inspected object is judged to be defective. On the other hand, in order to detect faults such as a stain or a small dirt, which indicates low luminance, the luminance is summed up for the subdivided windows each excluding a window corresponding to the manufacturing number and the number of the subdivided windows with luminance which exceeds the threshold is counted. Then, the number of the subdivided windows exceeds a predetermined number, it is judged that a fault is detected.

Figure 11 is a flowchart showing the processing of the windows each. The high speed image-processing apparatus 53 starts entrapping images to switch the personal computer 54 on. Then, the position of the image of the cigarette is detected with respect to the visual field S of the CCD camera 4 based on a first image information in Step 1, and luminance information of the single image from the high speed image-processing apparatus 53 is inputted in Step 2, and the processing of the windows each such as summing up the luminance of the windows each is carried out in Step 3. Then, the above steps from the step 2 is repeated for the six imaged in accordance with the judgment in step 4.

The processing of the windows each provides the sum of the luminance to judge the discoloration due to heater as described above in Step 5. Then, in Step 6, the position of the manufacturing number to be masked is detected to judge the presence of a hole (pin hole or tear) or a dirt in Step 7. As a result, the result of the inspection is outputted in Step 8. The above process is repeated after a high speed image-processing apparatus 53 starts entrapping the image.

Although cigarettes are selected as inspected object in the above embodiment, it is possible to inspect a long cylindrical object with large diameter. When a single camera cannot pick up an image, a plurality of cameras are used for picking up the image and the images which are picked up by the camera are combined to judge the inspected object.

As described above, in the present invention, the appearance of the cylindrical object is picked up by the camera while the image being axially divided into a plurality of images, and characters

and symbols printed on an axially predetermined area of the divided images are masked to add the luminance of the picked up images each, and the sum of the luminance is compared with a threshold to judge a defective product. Therefore, an object on which characters or symbols are printed can be checked to remove a defective product by picking up outer periphery of the object by a single camera. Further, the threshold is to be selected in accordance with the kind of the defect, which provide automatic detecting apparatus for various purposes.

Further, with the detecting apparatus according to the present invention, the inspected object can be transported horizontally without special rotating mechanism of the inspected object. That is, the inspected object can be rotated with ease by only placing the inspected object on a rotating roller having a chain-driven shaft, which provide simple transporting system.

Claims

1. An apparatus for inspecting appearance of a cylindrical object comprising:

rotating means for rotating the cylindrical object about an axis of the cylindrical object;

picking up means for picking up images showing the appearance of the inspected object which are axially and circumferentially divided into a predetermined number;

masking window generating means for generating masking windows for masking characters and symbols which are printed on an axially predetermined portion of said divided picked-up images of said inspected object;

detecting window generating means for generating detecting windows for extracting portions on said axially predetermined portion of said divided picked-up images of said inspected object on which said characters and symbols are not printed;

adding means for adding luminance excluding the luminance of said masking window for divided picked-up images each; and

comparing means for comparing said added luminance with a predetermined threshold,

wherein a portion where said added luminance exceeds the threshold is judged to be defective.

2. An apparatus for inspecting appearance of a cylindrical object as claimed in claim 1 further comprising subdivided windows which are obtained by further subdividing the detecting windows and counting means for counting the number of windows having luminance which exceed a predetermined threshold which is independently set for said subdivided windows each,

wherein the appearance of the cylindrical object is judged to be defective when said number of windows exceeds a predetermined number.

FIG. 1

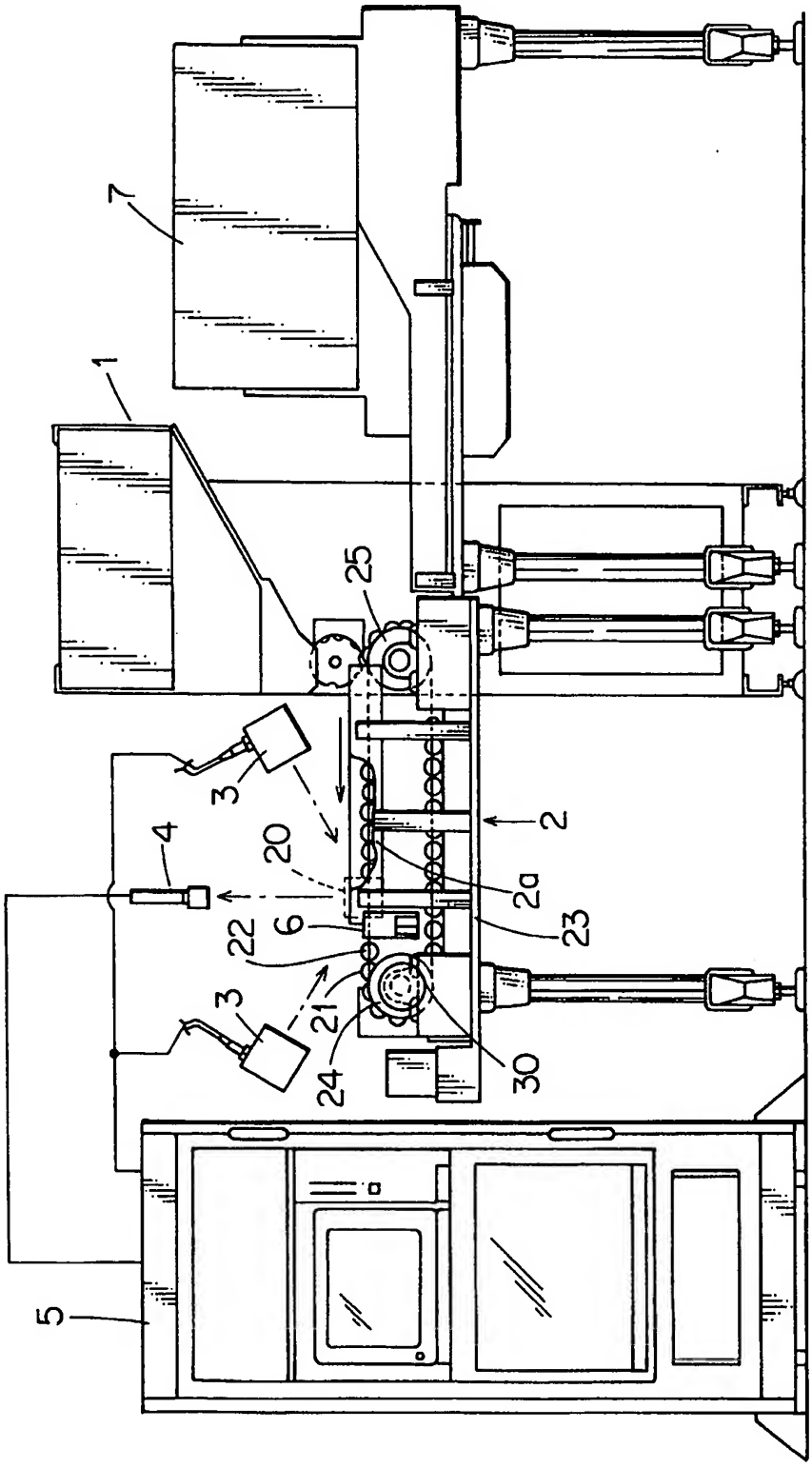


FIG. 2

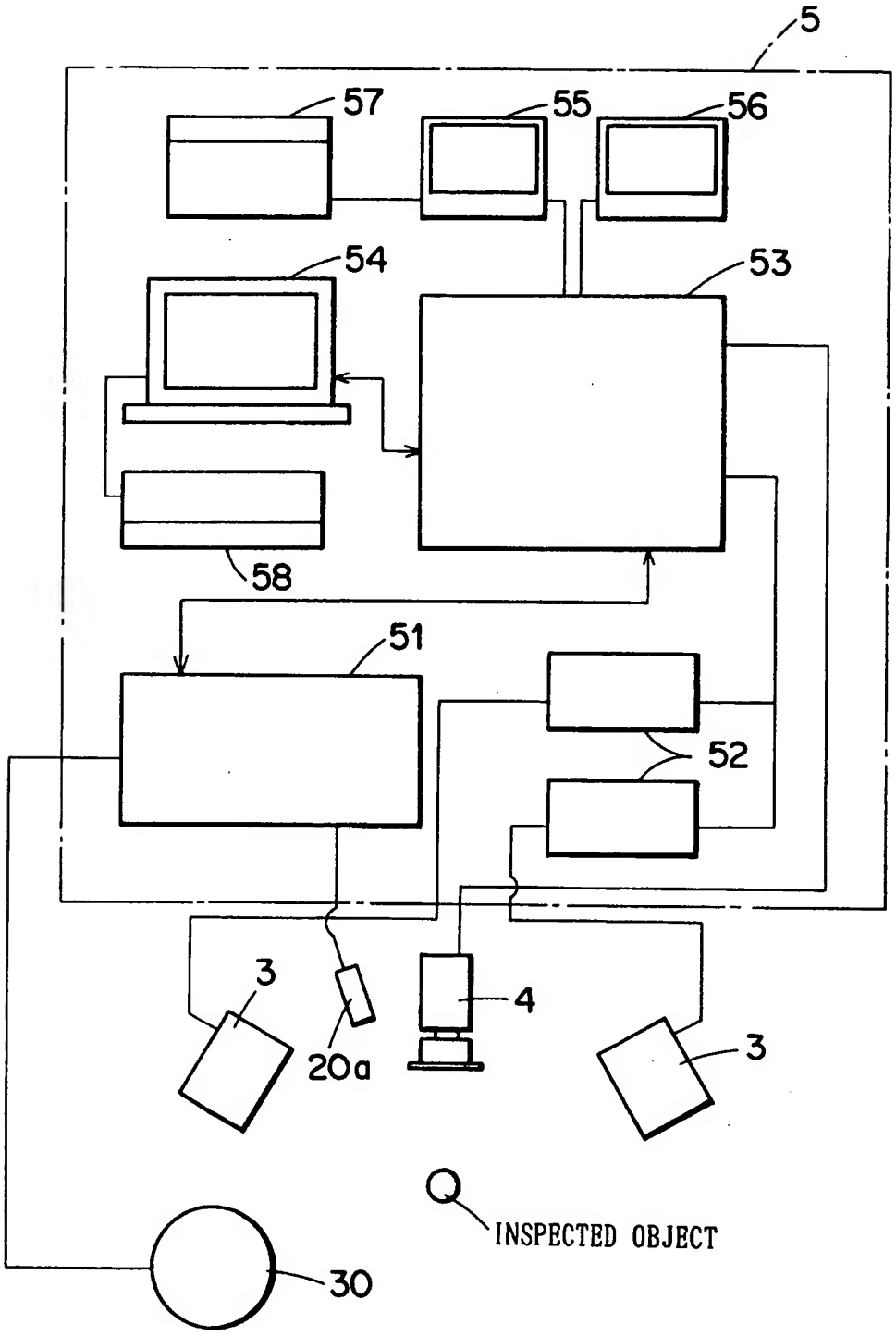


FIG. 3

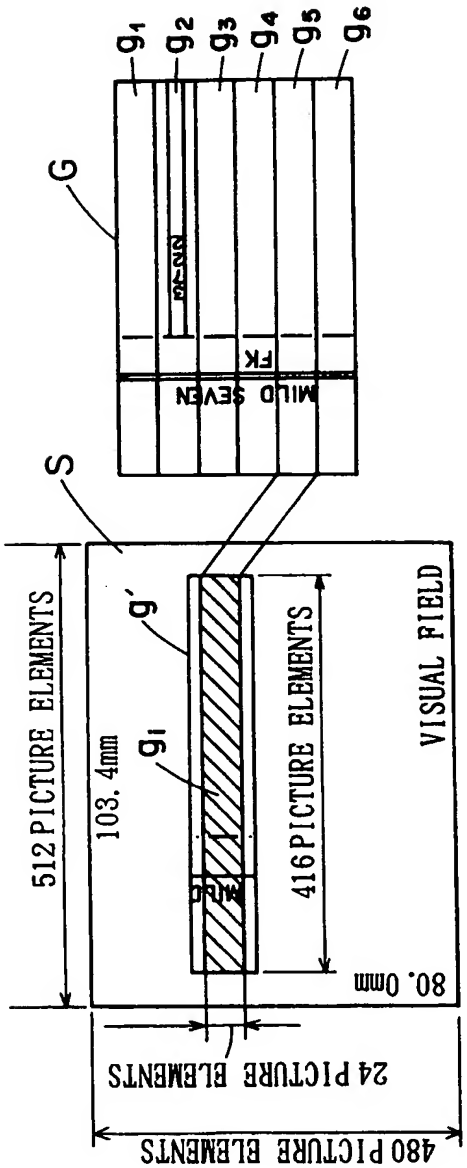

g1
g2
g3
g4
g5
g6
G
S
g'
g1
512 PICTURE ELEMENTS
103.4mm
416 PICTURE ELEMENTS
VISUAL FIELD
80.0mm
24 PICTURE ELEMENTS
480 PICTURE ELEMENTS

FIG. 4

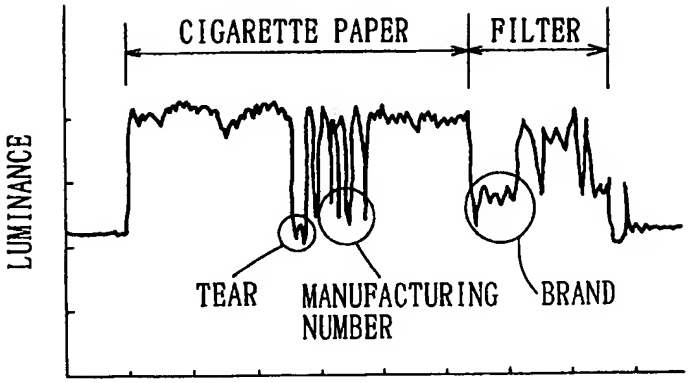

CIGARETTE PAPER
FILTER
LUMINANCE
TEAR
MANUFACTURING NUMBER
BRAND

FIG. 5

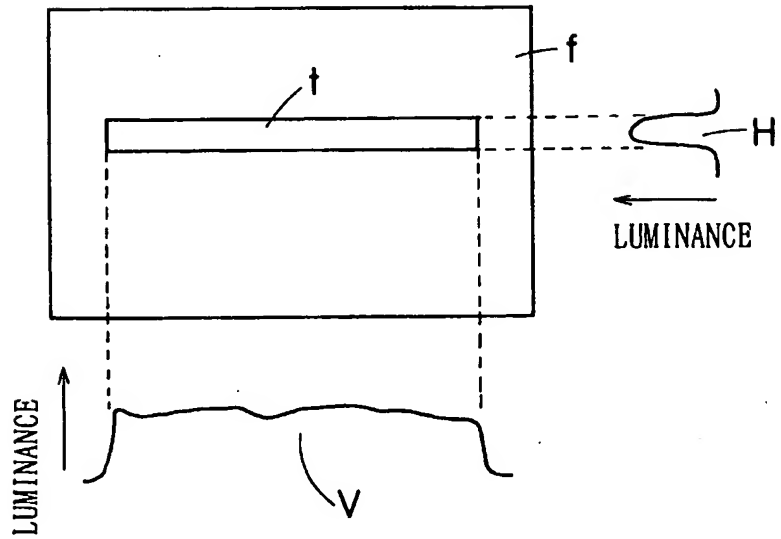

f
t
H
LUMINANCE
LUMINANCE
V

FIG. 6

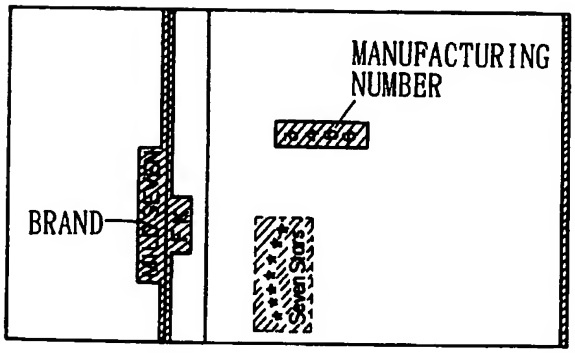


FIG. 7

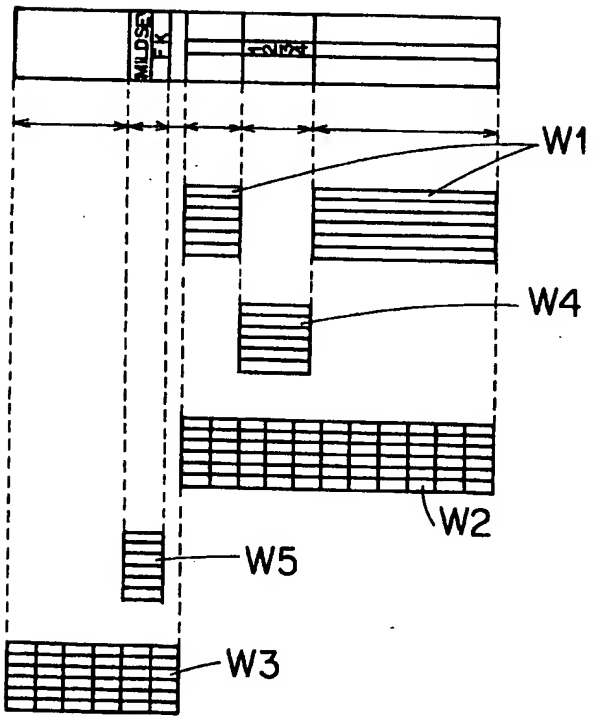


FIG. 8

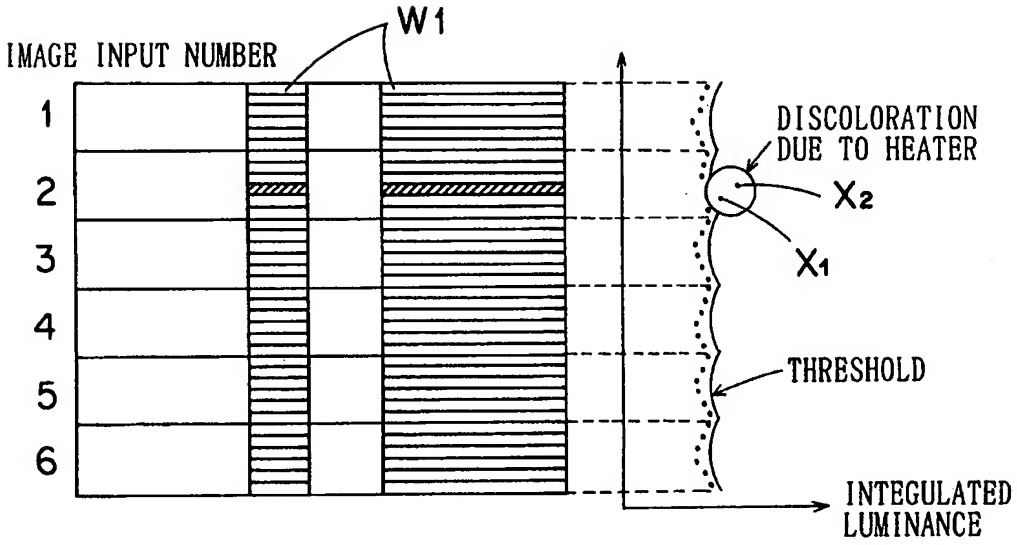

W1
IMAGE INPUT NUMBER
1
2
3
4
5
6
DISCOLORATION DUE TO HEATER
X2
X1
THRESHOLD
INTEGULATED LUMINANCE

FIG. 9

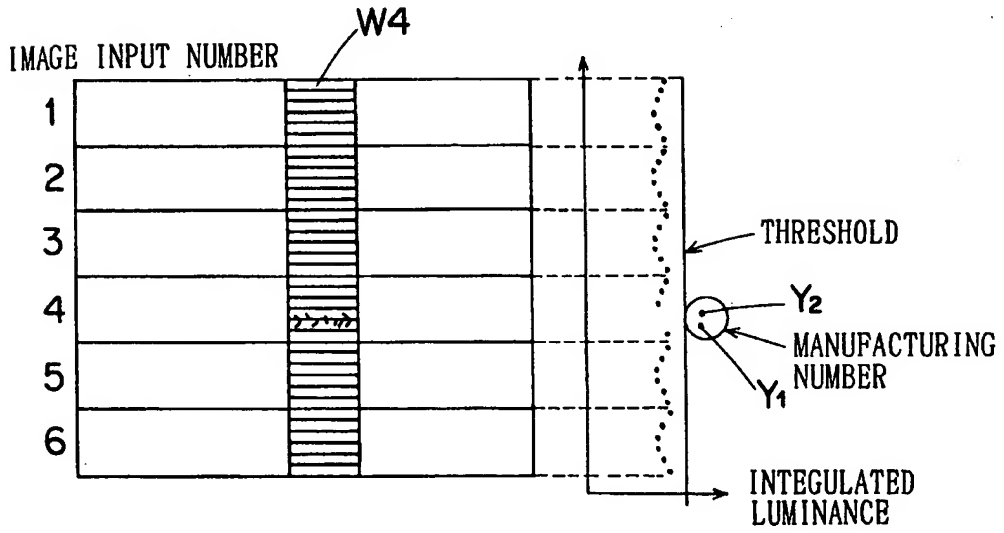

W4
IMAGE INPUT NUMBER
1
2
3
4
5
6
THRESHOLD
Y2
MANUFACTURING NUMBER
Y1
INTEGULATED LUMINANCE

FIG. 10

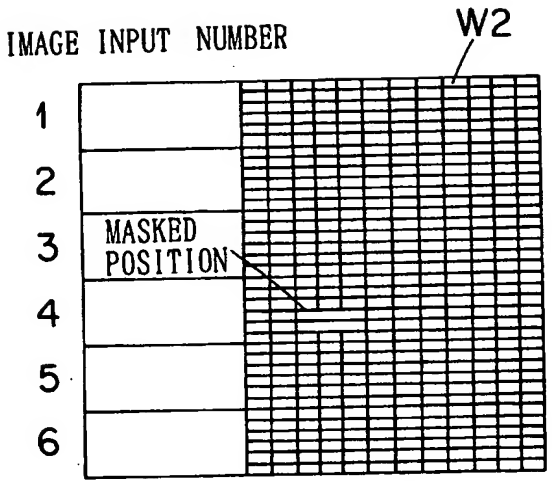
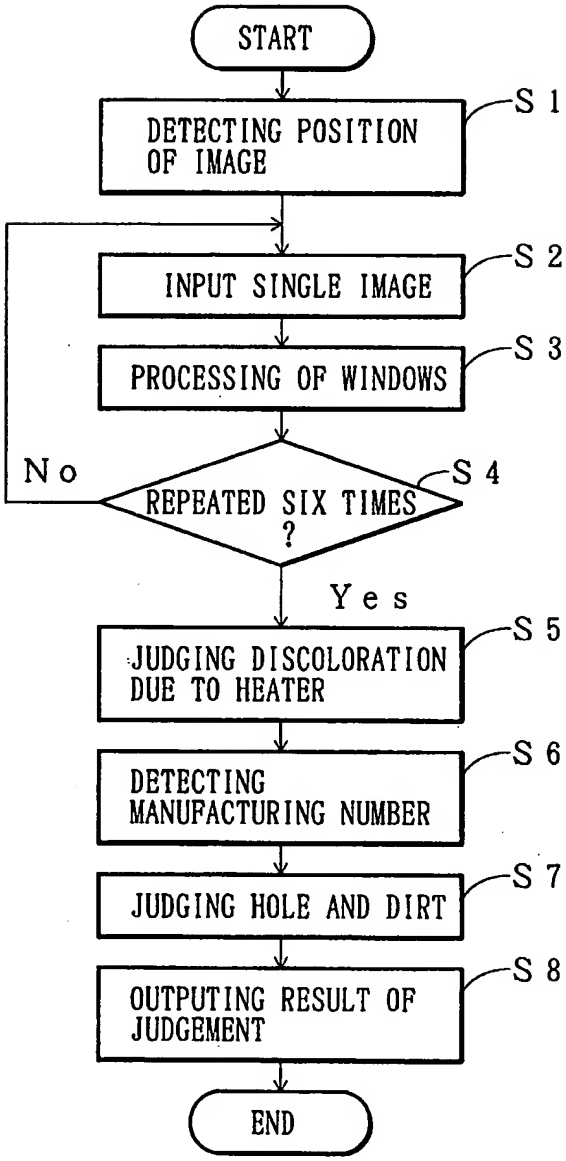


FIG. 11


START
DETECTING POSITION OF IMAGE
S 1
INPUT SINGLE IMAGE
S 2
PROCESSING OF WINDOWS
S 3
No
REPEATED SIX TIMES ?
S 4
Yes
JUDGING DISCOLORATION DUE TO HEATER
S 5
DETECTING MANUFACTURING NUMBER
S 6
JUDGING HOLE AND DIRT
S 7
OUTPUTING RESULT OF JUDGEMENT
S 8
END